New Developments In Mechanical Harvesting of Apples In Michigan

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ABSTRACT

Harvesting apples mechanically for processing outlets may soon be a standard practice as a result of a number of different types of mechanical equipment now being tested. Pick-up machines, low profile catching frames, trailers with a channel box, shallow individual containers and roll-out collecting units will be discussed.

INTRODUCTION

The 1968 apple production in Michigan was 12 million bushels. If climatic conditions were favorable, Michigan could produce 18 million bushels with existing apple planting. Because of labor shortages, the recruiting and managing of labor for harvesting apples has become a serious problem—one which must be solved if the present production is to be maintained.

About 50 percent of our apples are processed. Although processors cannot use deeply bruised or cut fruit, they can use fruit which has only surface bruises or injuries. Such fruit is good, but, because of appearance, is not suitable for fresh market. If the harvesting of processed apples can be mechanized, the available labor can pick by hand the apples for fresh market outlets.

Research conducted by the USDA in cooperation with MSU in 1959 and 1960 showed that apples suitable for processing could be detached from the tree by shaking and could be collected by using decelerator strips over a conveyer. The collecting unit was low profile so that it could move under the tree.

Some progress has been made since then, and last year (1968) several hundred thousand bushels of apples were harvested with machines. In

Michigan, modified cherry harvesting equipment, several roll-out units, and one "Perry"[3] harvester were used.

Because the available equipment is either expensive or results in too much damage to the fruit, research by USDA and MSU continues on all phases of mechanical apple harvesting.

A brief description of the 1968 work follows:

Shakers

In cooperation with the Friday Tractor Company,[3] a reciprocating hydraulic shaker which could operate in any direction from the vertical to the horizontal was designed and constructed. Tests of shaking apples indicated that vertical shaking was more effective than horizontal shaking in removing fruit. Fewer shaking cycles were required, and more fruit was removed. In fact, when limbs were shaken in the horizontal direction until fruit stopped falling, vertical shake at the same location resulted in further removal of fruit. Removing the fruit in fewer cycles should effectively reduce the bruising that occurs when the fruit is "fatigued" off the limb. The results obtained from this experimental shaker offer much encouragement for attaining an effective apple shaker.

Catching Container Harvester

This concept of an apple harvester consisted of four catching containers 16 ft. by 16 ft. placed like quarters of a pie about an apple tree. A one-quarter semi-circle with a 15 inch radius was on the center corner of the container. From the tree corner of the container an accumulation channel approximately 3 inches deep and 30 inches wide extended the diagonal of the square container. This channel was used as the main structural support of the frame. From the channel, two triangular wings composed of saran cloth stretched over steel tubing, extended on an 18 degree slope. A tree seal was added along the two edges adjacent to the other catching containers. One cloth drag strip was provided along both sides of the accumulation channel. These drag strips reduced the rolling velocity of the apples as they came down off the slope and went into the accumulation channel.

A fork lift tractor lifted the catching container from the corner that was diagonal from the tree seal. A pucker-sack made from saran cloth with a draw string was located in the accumulation channel next to the tree seal. Thus, after shaking, the catching container was lifted and tipped forward causing the fruit to roll down the accumulation channel to the pucker-sack hole. The pucker-sack was lowered into a pallet box and the pucker string released. The catching container was then lifted and the apples flowed into the pallet box.

This type of catching container has several advantages over the other harvesters which make this method of apple harvesting worthy of consideration. These harvesting frames will be low cost, have no moving parts, and are easy to store during the off season. At this time, the problems of maneuvering in the orchard, eliminating trash in the containers, and dumping the fruit into a pallet box have not yet been effectively solved. More tests will be conducted next season to determine the feasibility of this type of harvester.

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3. Trade names and manufacturers names are used for identification only and do not imply a recommendation.

All of the growers who have used a roll-out catching harvester commercially in Michigan have used the basic prune and nut harvesters from the west coast. These units have not been modified for apples by adding decelerator strips and padding exposed surfaces. A roll-out harvester was built and tested by the USDA research group during the 1966 season. This machine consisted of a conveyer that extended the full length of the catching cloth. A pallet box filler was added at the trailing end of the conveyer to permit the fruit to be lowered into the box with minimum dropping. The main conveyer frame was constructed on skids with detachable transporting wheels. A 35 hp. tractor pulled the unit down the orchard rows and supplied the hydraulic power to the harvesting machine. The catching canvas was 30 feet square when fully extended beneath the tree. Provisions were made for the tree by splitting the canvas from the extended edge to the middle. This cloth and the two layers of decelerator strips were rolled out manually. The cloth was dropped on the orchard sod and the decelerator strips were restrained by four portable anchors.

Samples evaluated at the processing plant showed: 1) 10.7% bruises on apples falling on the decelerator strips; 2) 27.8% bruises on apples falling on the canvas without decelerators; 3) 5.0% bruises on apples taken from hand pickers as a check. These percentages refer to the required hand trimming of bruised spots in the processing line for the Jonathan variety.

These results indicated that the roll-out harvester with decelerating strips had potential for apple harvesting. The 1966 tests also indicated that the size of this harvester was not a hindrance in the orchard. Capacity of the unit, equipped with one shaker, was approximately 90 bushels per hour. However, the manual labor necessary to pull the catching cloth and decelerating strips out beneath the trees was very exhausting. It was desirable, therefore, to extend the catching cloth and strip assembly by mechanical means. The addition of spur-eliminating rollers also was desirable.

Harvey Harvester Company,[3] Grand Haven, Michigan, employing information obtained from the 1966 tests, designed and constructed a roll-out catching frame for tests in 1967. The harvester was basically similar to that used in the 1966 tests, with the exception that the catching cloth and the decelerating strip assembly were mechanically extended and retracted. This machine required only two operators, one on the machine and another on the towing tractor. This prototype included spur-moving rollers at the end of the main conveyor belt. Steerable transport wheels were a part of the frame.

Although tests in 1968 were brief because of mechanical problems, this unit has possibilities. It is planned that the unit will be developed to a commercial stage and probably be made available to growers.

Pick-up Unit

A definite need has been expressed in Michigan by growers for an apple pick-up harvester. Because of unpredictable winds that can result in removal of the entire apple crop in a particular area or orchard, growers want a harvester that will recover this dropped crop. Pickers are, in many

cases, not available when wind damage has occurred. Therefore, the grower usually absorbs the entire loss of his crop those years when wind damage occurs. In addition to wind loss, apple drops occurring during maturity can amount to 5 to 20% of the total crop during a normal year. For light drops (0-10%), the pickers are usually not interested because they cannot earn satisfactory wages. For heavy drops (10-20%), the grower usually cannot get the necessary help to pick up the drops and pick the crop at the same time. So the higher cash value crop will be harvested first, leaving the drops until labor is available.

From our research tests of several methods of picking up dropped apples, we have concluded that one of the most promising mechanisms is a rubber disc roller. As the roller moves forward over the ground, apples become lodged between adjacent discs and are picked up by rotation of the discs.

A prototype unit was constructed and tested in 1967. The roller was three feet long and the discs were two feet in diameter. The discs, made from natural rubber, were covered on the outer radius and edge by polyurethane foam sheeting (two-pound density) having a vinyl skin. The roller was powered hydraulically, and the discs rotated at approximately one and one-half times ground speed in the direction of travel. A bar (floating shoe bar), located at ground level on the trailing side of the roller, helped to wedge apples between the pick-up discs. A cover of synthetic cloth extended from the bar to the top of the roller assembly. The cover helped to wedge and retain apples between discs as they rotated in an upward direction. The cloth was laced with a rubber cord, thus permitting the cloth to "give" with the flow of fruit on the discs.

Located at the leading edge surface of the disc roller assembly were a series of comb fingers extending between each disc. Here the fruit was lifted from between adjacent discs and then rolled onto the conveyer. Provisions were made on the prototype to convey the fruit onto a pallet box mounted on the unit.

Plans are to design and construct a trailer mounted pick-up unit for the 1969 season. It is hoped that a pick-up harvester will be available to the growers either in 1969 or 1970.

Handling Equipment

A pallet box handling unit called the "Swing Tote" was developed by the Friday Tractor Company. This unit was studied in a commercial apple orchard by our USDA group.

The "Swing Tote" is similar to a small "tournapull" with the addition of a fork lift boom on the front and a pallet box carrying conveyer on the back. The forks are pushed under a box which is lifted, and the fork lift boom, power-driven assembly, and the operator are then rotated 180 degrees. The pallet box is positioned and lowered onto the pallet box conveyer chain which moves the box to the rear of the unit. After the loaded pallet box has moved off the forks, the fork lift mask, drive assembly, and operator are rotated 180 degrees or more and the "Swing Tote" moves on to the next box. A total of four boxes can be carried on the chain conveyer and one box on the forks.

The unit maneuvers easily about the orchard rows and roadways. Unloading the boxes can be easily accomplished by lowering the rear portion

of the conveying chain to the ground and driving forward as the pallet boxes are conveyed off the back of the unit. Pallet boxes can also be unloaded by the fork lift in the same manner as they were loaded. They can either be placed on the ground or loaded on the truck. Functionally, this unit performs effectively all the operations for which it was designed.

Quality Studies

The main concern during the development of mechanical apple harvesters is the maintenance of acceptable fruit quality. Serious bruising during harvest has many undesirable consequences. A grower not only loses fresh market outlets, but he also suffers financial losses at the cannery. Unlike the case with tart cherries, apples can be scored objectively for bruise damage by the raw product inspector. When 5% or more of an apple, by weight, is bruised, its value drops from about 4.3¢ per pound to 2.0¢ per pound (1968 prices). The bruised apple is downgraded to the cider class.

Damage By Hand Pickers. Estimated dollar losses to growers from harvest bruising in 1968 are shown in Table 1. Hand pickers varied widely in the amount of bruise damage they caused. For example, the five most careful pickers of the 60 pickers tested delivered fruit having no bruise damage. In contrast, the five roughest pickers damaged 18% of the fruit. To a 10,000-bushel grower, the 18% bruise damage meant a loss of about $1,820. Unfortunately, hand pickers are becoming increasingly careless.

Mechanical Harvesters Varied. A few Michigan growers harvested apples mechanically on a commercial basis in 1967 and 1968. One grower used equipment and methods that minimized bruise damage (Table 1, harvester A). For instance, average damage (11%) was less than that of careless hand pickers (18%), and not much greater than that of the average hand picker (5%). About one-half of the machine harvested apples were suitable for fresh market outlets. The harvester was equipped with decelerator strips, and other anti-bruise devices. These results prove that quality can be maintained during mechanical harvest.

A mechanical harvester that was not designed especially to minimize bruising caused excessive damage. The 40% damage obtained with harvester B (no decelerator strips) would cost a 10,000-bushel grower about $4,050 under normal circumstances (Table 1). However, during the developmental stages of mechanical harvesting, some forward-looking processors accepted bruised apples without penalty. The bruised lots were blended with hand-picked lots and processed promptly. A wise grower will select a harvester that gives maximum protection against bruise damage.

Losses During Yard Storage. In early season, freshly harvested apples commonly are stored for ten days or more in processing plant yards. This holding period is needed to "condition" apples for easy evacuation of tissues during processing. During early October, 1968, we measured the weight losses of Jonathan apples (11 lots) stored in a plant yard for ten days at prevailing temperatures (45°F to 85°F). As might be expected, the losses depended partly on extent of bruise damage (Table 2). The most bruised apples suffered the greatest weight loss (2.12%). In terms of dollars, this loss to the processor was equivalent to about $403 per 10,000

bushels. These results again stress the desirability of controlling harvest bruising.

USDA Trailer Harvester System

This apple catching system will consist of two catching trailers, each trailer constituting one-half of the catching frame system. Each trailer will have two transporting axles approximately 10 feet apart in the center of the 32 foot main bed of the unit. The central part of the frame will consist of a steel metal box (14″ x 6′ x 32′) and will be padded with cushioning material on the inside surfaces. This channel box will be the container for collecting the fruit during harvesting.

On both sides of the channel box will be two 5 foot saran covered wings that extend the entire length of the frame (32′). Both wings will be hydraulically controlled, positioning the outer edge of the wing from ground level to a vertical position. This system will have a right and left catching frame. Thus, one of the saran wings of each half will have a tree seal that will extend hydraulically after the wing is in position next to the tree. Deceleration strips will cover the entire frame, giving one layer on each wing and two layers above the center channel box area.

Both halves will be powered hydraulically and pulled mechanically by a conventional 30 hp. farm tractor. When positioned beneath a tree to be harvested, the wings will be lifted and the tree seal extended to overlap the matching half. A tractor or frame mounted shaker will have been positioned and ready to shake as soon as the frames overlap. The shaking will commence when the frames are in position, and any additional connection to different limbs will be made, if necessary, to detach the fruit. When the last limb has been shaken, the tree seal will be retracted and the wings lowered for limb clearance. The frames will then be pulled into position beneath the next tree to be harvested.

The holding capacity of this system will be between 200 to 360 bushels of apples. Thus, the number of trees that can be harvested before unloading the frames will be between 15 to 30 trees, depending on the crop.

After the harvesting frames are loaded with fruit, the side wings of the frames will be lifted in a vertical position and the two frames will be taken to an unloading station where the fruit from the channel box will be flushed, dumped or conveyed out. The unloading station will have facilities and equipment to remove the leaves and spurs from the fruit as well as to convey the fruit into a truck bed or pallet box. If loading ramps are available, the harvester will be backed over the pallet box (either on the truck or ground) and the fruit dumped directly into the pallet bin. In this case, bulk handling could be employed by dumping the fruit directly into the truck bed. For this latter method of handling, spur and trash eliminating equipment will be installed at the processing plant. After the harvesting frames are unloaded, they will return to the orchard to continue harvesting.

Summary

Much effort is being put into the development of mechanical harvesters for apples by growers, manufacturers, processors and researchers. Considerable progress has already been made. With this continuing cooperative

effort, mechanical harvesting of processing apples should become a reality on a large scale in the near future.

TABLE 1. *Apple growers are penalized at cannery for bruise damage. Hartford, Michigan, October 1968.*

Sample description	Bruised apples, percent	Estimated dollar loss to grower from bruise, per 10,000 bushels
1. Hand picked, commercial, least bruised (5 lots)..	0	0
2. Hand picked, commercial, average bruise (60 lots)	5	$ 510
3. Hand picked, commercial, most bruised (5 lots)..	18	$1,820
4. Mechanical harvester A, average bruise (9 lots)..	11	$1,110
5. Mechanical harvester B, average bruise (2 lots)..	40	$4,050

TABLE 2. *Weight loss of apples during storage in processing plant yard. Hartford, Michigan, October 1968.*

Apple sample	Weight loss during 10 days of yard storage, percent	Estimated dollar loss to processor per 10,000 bushels
Control, not bruised.....	1.64	$312
Medium bruise.....	1.79	$340
Severe bruise.....	2.12	$403